Quality Concrete for Highway Construction With Central Mixing Plant

GLENWAY MAXON, Consulting Engineer
Milwaukee, Wisconsin

Central mixed concrete, delivered to job by new agitated truck bodies, offers great opportunity for fast placement, new methods of quality control, and versatility in respect to placing concrete in bridges and the numerous other structures as well as the slab itself.

The method is fundamentally old. Figures will show work in Ohio during 1921.

The first large scale operation along modern lines was the concreting on one section of the Ohio Turnpike in 1954.

There were two large scale operations in 1955 and numerous smaller operations where only part of the concrete was central mixed.

Improvised plants such as stationary truck mixers, and stationary pavers permitted the use of equipment already available. This was affected on the Garden State Parkway widening, June 1955, and odd parts of US 14 in Ohio near Ravenna, such as bridge approaches, intersections, and the like.

The need is shown for new equipment including a spreader to convey and deposit the concrete evenly across a full 25 foot width of pavement. Portable, or semi-portable, concrete mixing plants are also needed which can be transported in parts for rapid travel and erection. These plants should incorporate complete facilities for automatic weighing, recording and testing.

It is proposed that the heavy media method of testing for cement content be enlarged to test the first, middle, and last parts of the concrete as discharged from the central mixing plants to measure uniformity of mixing.

In respect to placing concrete in the slab a device should be tried for consolidating by using both pressure and vibration in order to successfully place concrete of one inch or less slump.

With the added flexibility and speed, central-mixed concrete may well improve quality and reduce cost of concrete in our country's new highway program.

● CENTRAL-MIXED concrete for use in the construction of highways has a great future in reference to economy, rapidity, and quality. By grouping the manufacturing elements of batching and mixing, the opportunity for higher production rates and less costly inspection are available.

The design of equipment for easy inspection, should be paralleled with simple and quick testing methods. Tedious testing methods, frequently lead to their curtailment or are carelessly applied.

All personnel should be made cognizant of the ways and means for controlling quality of the concrete for it takes team work to insure the best concrete between the forms. (Figures 1 and 2).

Concrete has been placed in road construction by non-agitated delivery from central mixing plants as far back as 1913. (Figure 3).

Flexibility of Central Mix

Central mix plants can quickly switch from Class A to Class B concrete and can further batch out and mix concrete for precast, and prestressed concrete where water content is at a very minimum. Isolated placements of widened intersections, curbs and gutters, culverts, retaining walls, maintenance buildings, etc., can all be served with concrete from a central mixing plant without disturbing the set up for slab con-

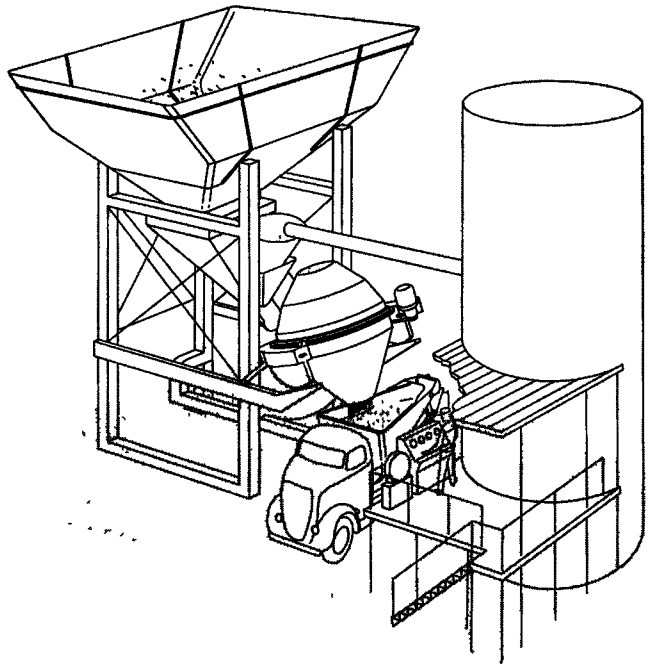

Figure 1. Diagram of elements. Plant - operator and test floor - Agitor delivery.

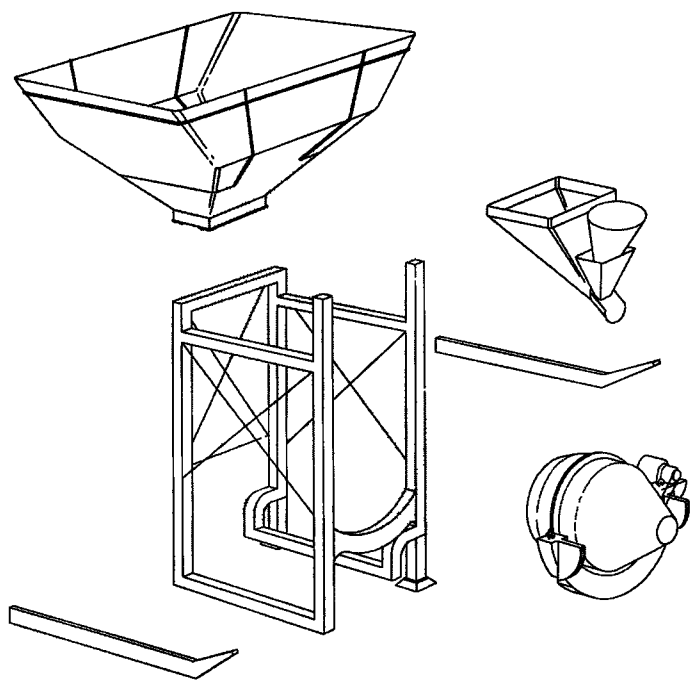

Figure 2. Diagram of elements. Exploded view of plant.

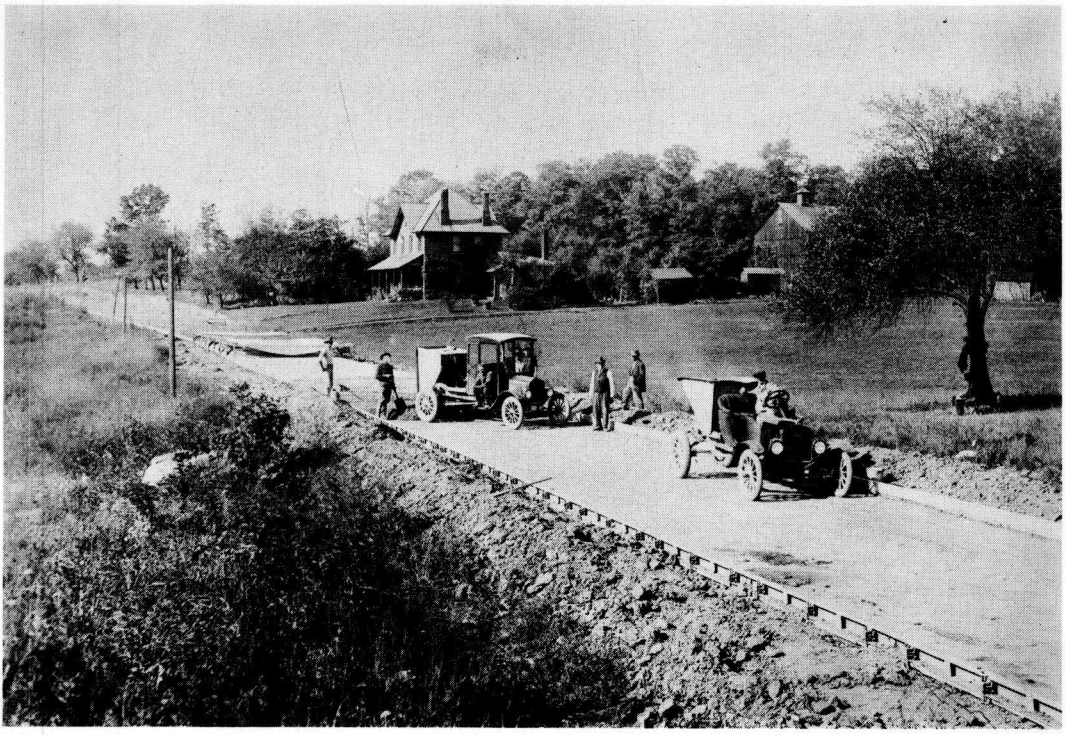

Figure 3. Highway job in Ohio, Columbiana Lisbon Road, September, 1921.

struction. Concrete for these can be placed when weather or subgrade conditions make slab placement impractical. (Figures 4 and 5).

Control

Automatic control of weights, of aggregates, water, cement, and the mixing of these can all be viewed by one operator and checked by one inspector. Today, mixing plants with plug-in electric connections can be quickly moved. The set up costs are not much greater than the set up of present day batching equipment. Tear down and new set up should be made within two weeks with plants designed with that in mind. (Figure 6).

Recording

For projects for government work, and where required in airports, expressways, etc., devices for recording the amount of cement in each batch can be had for an additional $5,000., and for another $7,000., devices for recording aggregate may be included. With central mixing, moisture control is comparatively easy, particularly if the operator can be located at the discharge end of the mixer, where he can look within the drum and by experience determine the slump of the concrete before discharge. (Figure 7).

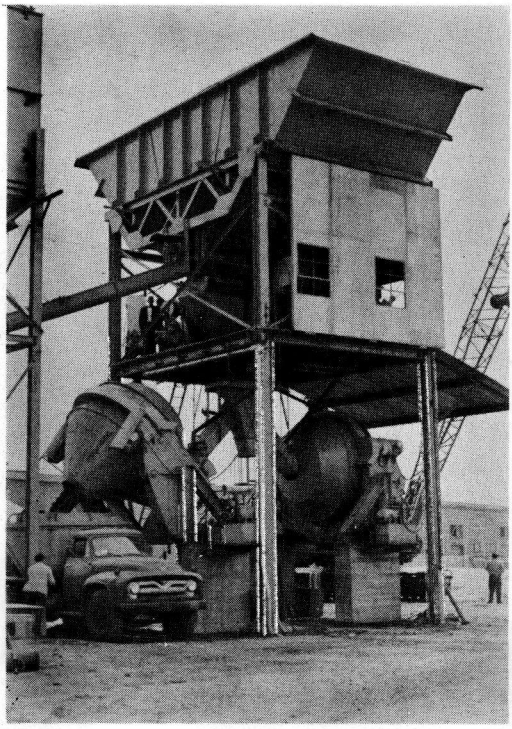

Figure 4. 4 cu. yd. mixer and dumpcrete. New Jersey Turnpike Extension.

Speed of Mixing

In mixing concrete in a mixer of this type there are numerous methods of speeding up the cycle. Material for 4.4 yards of concrete can be placed in this mixing drum in the course of 15 seconds. At the same time, the water injection should be speeded up

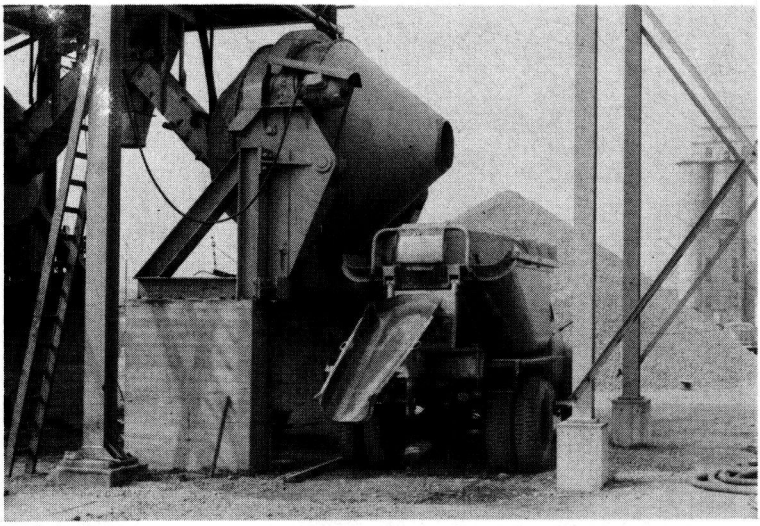

Figure 5. Brewster mixer, New Jersey Turnpike Extension.

by applying pressure, very possibly injecting it from the opposite end of the drum or from both ends. Mixing time, after all the ingredients are in, should not be more than one minute and fifteen seconds. Complete tilting to discharge, and return for the next load requires fifteen seconds. With such a cycle, this mixer can turn out 150 yards

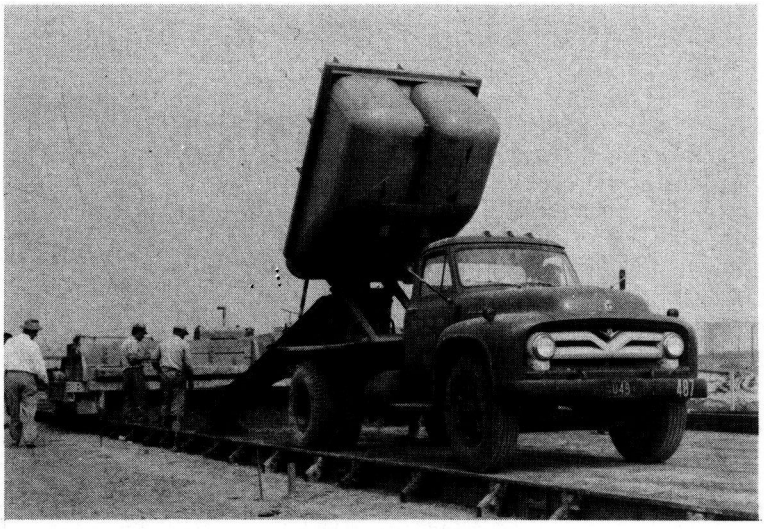

Figure 6. Placing concrete from Brewster plant, New Jersey Turnpike Extension.

per hour, a quantity sufficient to build 225 feet of 24 foot pavement 9 inches thick. It is possible that this cycle can be somewhat speeded up. In any event, it has the approximate capacity of two 34-E pavers. The tilting mixer has a record for reliability which is not surpassed.

Placing and Spreading on Slab

The placing of concrete on the slab entails no serious problem. It is possible now to mix and place the equivalent concrete of several pavers at one location without taking

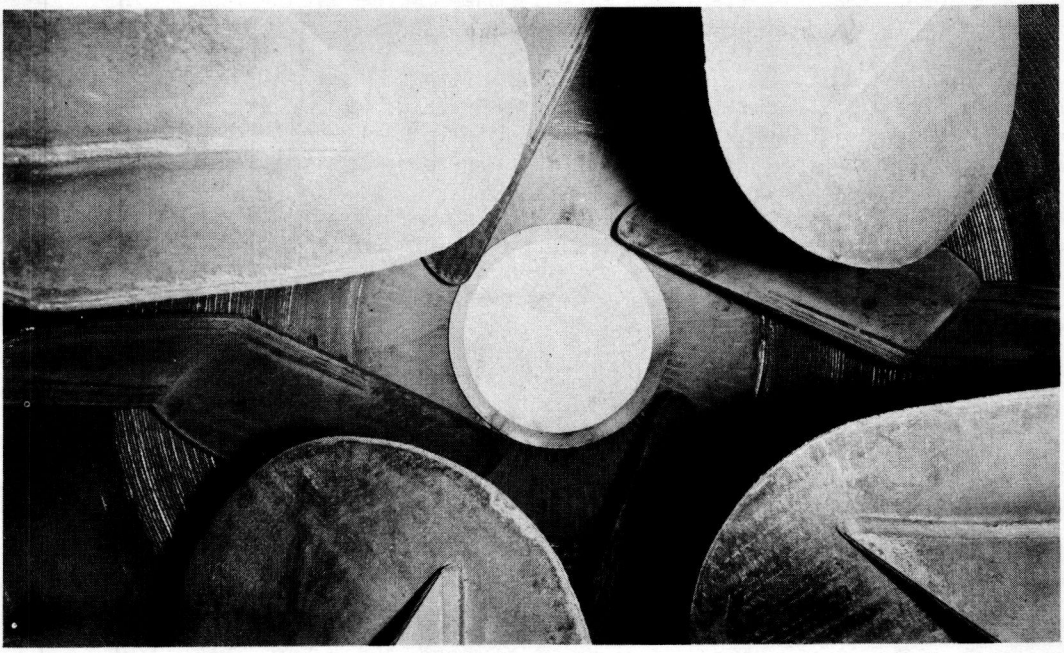

Figure 7. Inside of mixer.

up much room on shoulders. (Figure 8). Where the slab has width wider than that which can be spouted from a non-agitated high discharge concrete body, a conveyor

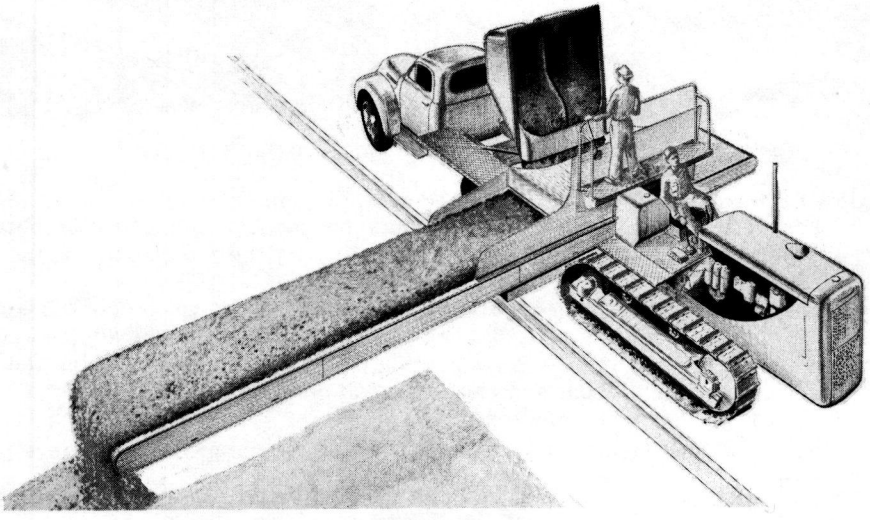

Figure 8. Shuttle belt conveyor. Mounted on Caterpillar D-8 for spreading concrete on 25-foot widths.

can be provided for moving concrete to the far side. Such a conveyor is shown in the figure. This conveyor was developed by W. D. Winkelman Company. (Figures 9 and 10).

Placing Auxiliary Concrete

The instruments for placing concrete on bridges, curbs, gutter, retaining walls, and interchanges, are similar to those used now with the stationary mixers, pavers, or truck mixers. Where pavers are used for mixing concrete for the slab, the same may be set up as stationary mixers for placing the miscellaneous concrete. (Figures 11 and 12).

Testing and Inspection

At the present time there are no widely used methods for testing the degree of mix of fresh concrete. A simple mixer efficiency test is much to be desired. The heavy media method of determining cement content, together with an easy means of determining the amount of segregation of various portions of the batch, is needed. Some of the expense of making compressive and flexural strength samples might be transferred to mixer tests. If these mixer tests are shown to have a relationship with seven and twenty-eight days strengths, their use would be of value to both the contractor and contracting officer in quality control as mixed, rather then attempting correction after a month in place.

Even though tests of fresh concrete may not tell the whole story, a diagnosis should

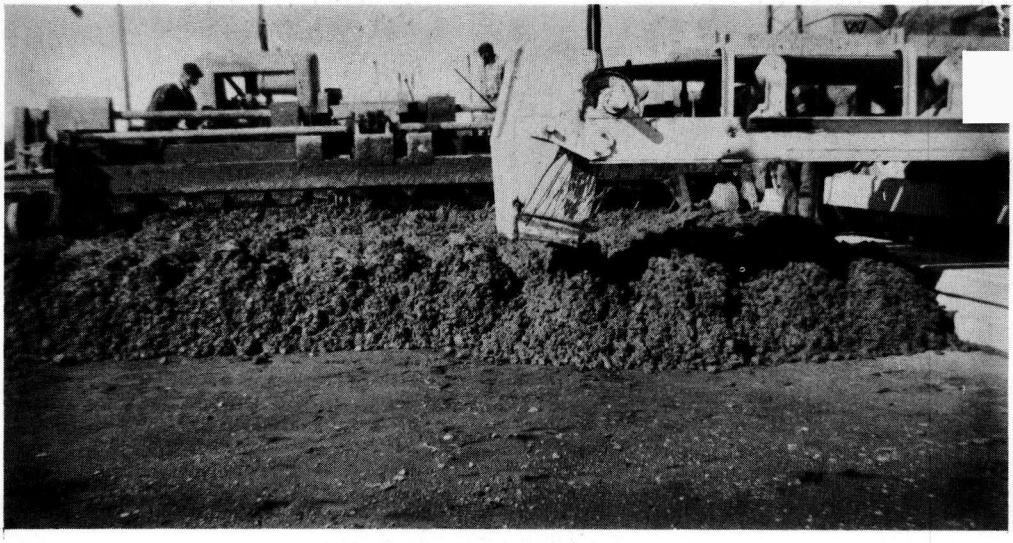

Figure 9. Spreading dry concrete, Plattsburg Air Base.

be made before failure, rather than holding an autopsy some 28 days too late. The cooperation between the contractor and the engineering inspector can best be obtained by simplifying the job of inspection at the time we simplify the job of manufacturing the concrete.

When 700 psi, is called for in flexural strength it is imperative to check frequently for errors in batching and mixing. Daily checks of material should be augmented by daily checks of mixer efficiency. I am suggesting one method of check using the heavy media method of separating cement and sand in fresh mortar.[1]

The ball penetration test takes much less time than the slump cone.[2] (See Figure 13 for variation of this method.) The Chace Air Meter can be carried in one's pocket.[3]

---

[1] A Method for the Determination of the Cement Content of Plastic Concrete by W. G. Hime and R. A. Willis published January 15, 1955, by the Research & Development Division of the Portland Cement Association. (See brief description in Appendix.)

[2] See ASTM Specification - 55.

[3] The Chace Air Meter has been used quite successfully by Howard, Needles, Tammen & Bergendoff on bridge approaches and slab work on the New Jersey Turnpike extension from the Newark Airport to the Holland Tunnel. It is manufactured by L. M. Chace,

With it, one man can make a test for air content in the course of ten minutes.

Continued sampling and testing, instructing labor and management of the reasons for testing, together with simplifying the methods of testing, are steps to improving and controlling quality. Management and the people working are just as proud of good work as any skilled employees in the quality manufacture of shoes or automobiles. We make a grave mistake when we don't strive to cultivate their interest. The sidewalk inspec-

Figure 10. Plattsburg Air Base. Dumpcrete depositing in hopper, (Note ''Tourna-Dozer'' to which belt conveyor is mounted).

---

[3] (footnote continued)
North Bridgton, Maine. A small sample of the mortar is taken and placed in a cup immersed in alcohol and agitated to remove the air. The drop in the gage is then compared to the chart, which had previously been computed with the aid of the standard meter.

tion holes on building projects affects the pride of the workman within. A group trip of visitors through a factory has a salutary affect on the workers. The pride of quality

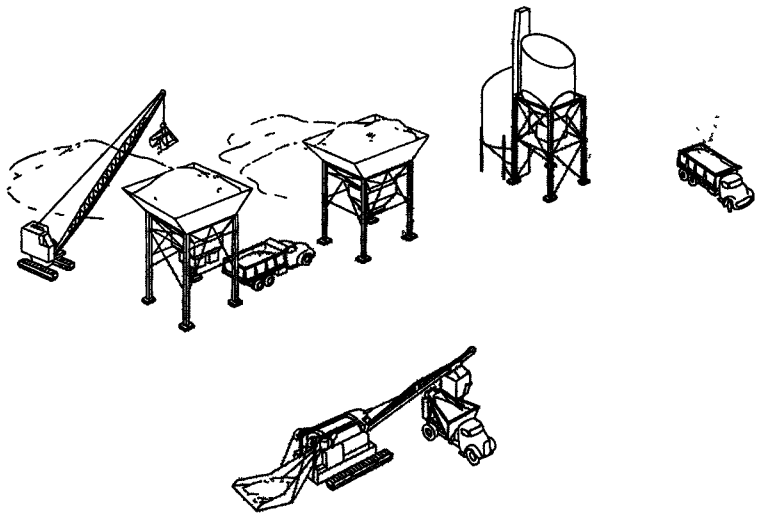

Figure 11. Bins, trucks and paver - AGITOR delivery.

should be in evidence on the company's bulletin board, and should be displayed as prominently as that of safety records. Quality control for highway concrete means 5,000 psi. compressive strength concrete, 700 psi. flexural strength, and the designed air

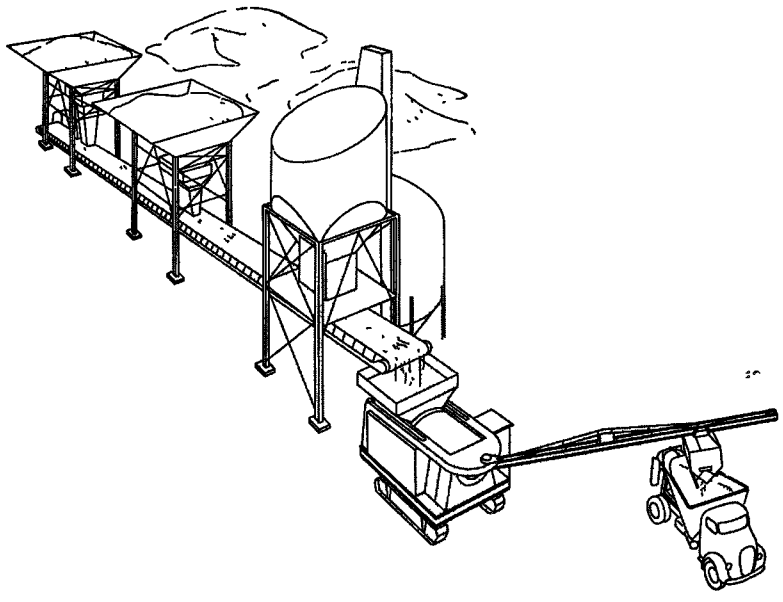

Figure 12. Bins, belt conveyor, paver - AGITOR delivery.

content; also not far in the future, the manufacture of no slump 7,000 to 8,000 psi. concrete for prestressed members.

Quality control should lead to better uniformity. There should be no variation of 20 percent. Equipment can be designed to control the strength within a variation of 10 percent, and to control other qualities which are required to be uniform.

The Heavy Media Method has been put to use by the New York State Department of Public Works.

The tests were carried on by Ralph Hollweg, structural supervisor of District No. 10 during the summer of 1955. M. E. Goul is District Engineer. Their operations cover Nassau, Suffolk, and counties in Greater New York. The tests were made by Cellini under Hollweg's supervision. The laboratory room is about 10- x 12- ft. In the tests I viewed about ten of us crowded into that room and still left room for testing. Both Cellini and Hollweg spoke well of the method. I took five stereo photographs showing: separation through 30 mesh screen, drying in skillet, dried sand and cement, with centrifuge in background, filling centrifuge test tubes, test tube with cement and sand separated. (Sand floating on heavy media.)

Placing Dry Concrete

No great progress has been made towards consolidating dry harsh mixes in pavements. Means of combined pressure and vibration should be explored. These methods

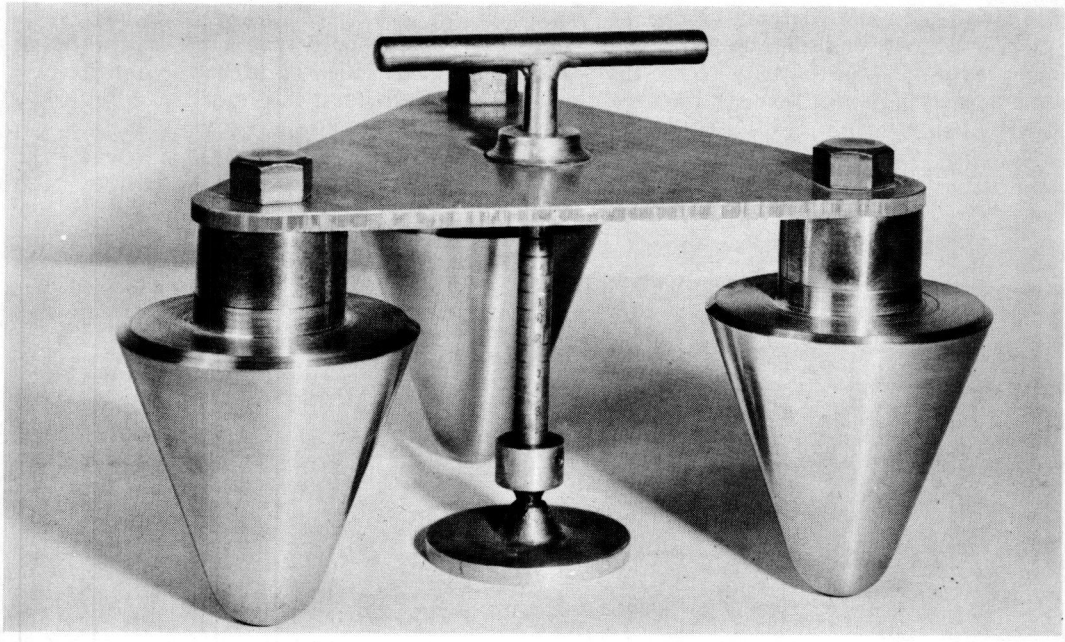

Figure 13. Three point penetration tool, similar in principle to Kelly Ball.

have proven of great value in the manufacture of concrete products. The very old method of hand-tamping with a square tamper might be emulated by machine methods, vibrating the tampers as pressure is applied. If such machinery be devised, there is no reason why 0 to 1-inch slump concrete cannot be placed without voids or honey combing as economically as the 3-inch to 4-inch slump concrete now prevailing.

In conclusion, the design of equipment, the planning of work, and systematic inspection, are items which must be correlated for mass production and quality control of concrete roads.

Appendix

The Hime-Willis test for cement content can be made within 1 hour 15 minutes. Several tests can be processed simultaneously. The elapsed time for three tests should not be more than 1 hour 45 minutes. That is all that would be required to check cement distribution in the mortar from first, middle, and last part of the mix.

1. In field tests - samples of approximately 50 lb. are taken from the mix.
2. A representative part of about 4 lb. is taken from the sample. Its exact weight is recorded.
3. The sample is wet sieved in a beaker through 30 mesh sieve. The minus 30 in the beaker is then collected after decanting the water and placed in a skillet.
4. The contents are dried, broken up and weighed.
5. Two samples of 25 grams each are taken and introduced into two 50 ml. graduated centrifuge test tubes.
6. The tubes are filled while stirring to 50 ml. mark with a mixture of acetylene tetrabromide and carbon tetrachloride of specific gravity less than cement and more than sand.
7. The tubes are placed in a centrifuge and spun for several periods of 3 minutes each, stirring in between periods.
8. The volume of the cement content is read and recorded.
9. By comparing the cement content to the weight of the dried sample and then comparing to laboratory mixes a transfer in contents can be computed from the volume of the cement layer to sacks per cubic yard in the concrete being tested.
10. By checking the yield of the entire mix and taking three samples, front, middle, and rear, the cement content can be checked, the cement distribution determined and the stone and sand contents computed.
11. The test can then be a continual check on the aggregate scales. Flexural beam samples might well be taken from the same batch. Continued uniform cement distribution, and uniform flexural strength being the desired result in the quest of better quality control.

Note: Items 10 and 11 are suggested by the author.